RESEARCH AND TECHNOLOGY ADVISORY COUNCIL

COMMITTEE ON MATERIALS AND STRUCTURES

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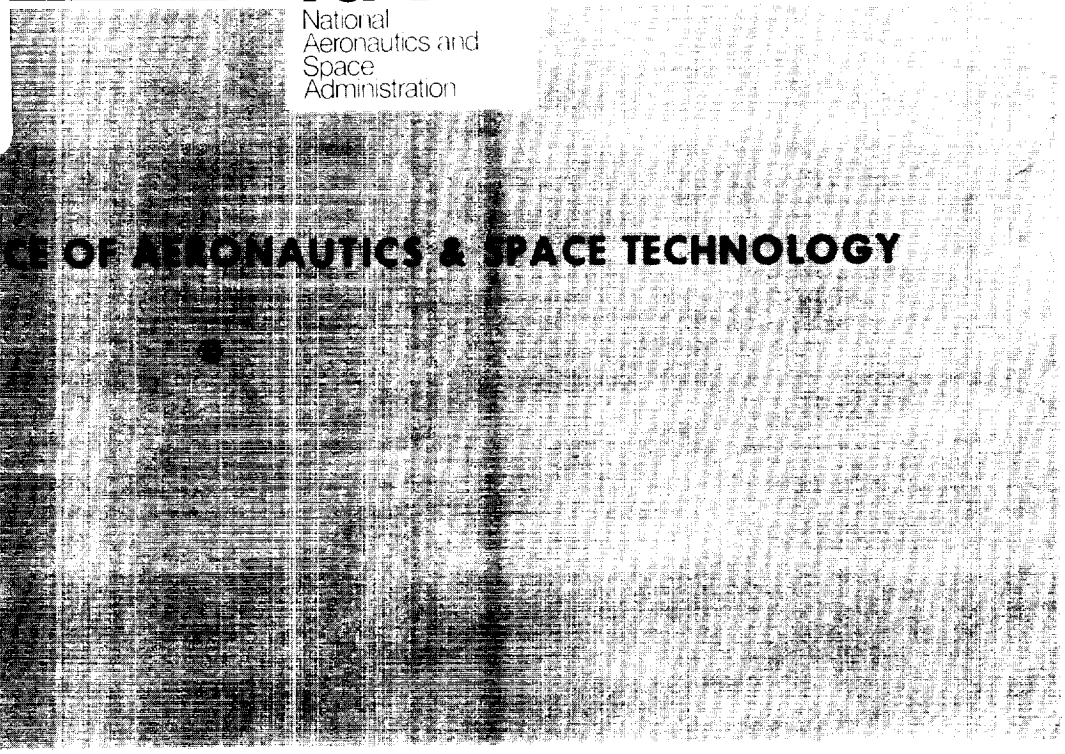
MINUTES OF MEETING

MARCH 25 and 26



SUMMARY

The eleventh meeting of the NASA RTAC, Committee on Materials and Structures was held on March 25 and 26, 1975, at NASA Headquarters in Washington, D.C. The meeting was open to the public.

The Committee recommended the following:

1. Critical Aerospace Materials

   Continued NASA studies and research on substitutes for chromium and nickel in superalloys and stainless steels for both aerospace and non-aerospace application as a long term solution to the consumption of these critical materials.

2. Engine Turbine Life Prediction

   Continued development by NASA and other agencies of life prediction models for engine turbine blades and verification of these methods by component tests.

The Committee studied questions by Dr. Lovelace concerning the NASA technology program and responded as follows:

1. Early Data Dissemination

   Digests, issued quarterly or bi-monthly by NASA Centers, covering various disciplinary areas and reporting significant new items were recommended, in addition to other types of reports now being issued.

2. Workshops and Seminars

   Mini-symposia type meetings were especially recommended. Specific topics were suggested.

3. Program Balance

   Greater emphasis on the NASA base technology program with increased in-house research was recommended. Specific areas were suggested.

4. Improved Design for Reduced Fuel Consumption

   Higher temperature materials in engines, composites in structures and engines, active controls, and improved seals in engines were recommended.

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NASA RESEARCH AND TECHNOLOGY ADVISORY COUNCIL
COMMITTEE ON MATERIALS AND STRUCTURES

Members in Attendance

Chairman - Dr. Holt Ashley
Stanford University

Dr. George S. Ansell
Rensselaer Polytechnic Institute

Ms. Joan B. Barriage
Federal Aviation Administration

Mr. Ira G. Hedrick
Grumman Aerospace Corporation

Dr. Robert I. Jaffee
Battelle Memorial Institute

Dr. James W. Mar
Massachusetts Institute of Technology

Mr. Edwin M. Ryan
Naval Air Systems Command

Mr. Howard J. Siegel
McDonnell-Douglas Corporation

Mr. William T. Simpson
Eastern Airlines, Inc.

Mr. M. Jonathan Turner
The Boeing Company

Mr. Francis L. VerSnyder
Pratt & Whitney Aircraft

Mr. Robert W. Hall
NASA Lewis Research Center

Mr. Richard R. Heldenfels
NASA Langley Research Center

Mr. Dell Williams, III
NASA Ames Research Center

Executive Secretary - Mr. George C. Deutsch
NASA Headquarters, OAST

Recording Secretary - Mr. Norman J. Mayer
NASA Headquarters, OAST

Members Absent

Mr. Charles E. Cataldo
NASA Marshall Space Flight Ctr.

Mr. George P. Peterson
Air Force Materials Lab.

Mr. Robert E. Vale
NASA Johnson Space Center

Guests

Mr. Bernard Chasman
Air Force Materials Lab.

Mr. William H. Kinard
NASA Langley Research Center

Mr. Colin G. Simpson
Federal Aviation Administration

Dr. Malcolm A. Smook
E. I. duPont deNemours & Co.

Other Participants

(Materials and Structures Division, OAST)

Mr. Bernard G. Achhammer
Mr. James J. Gangler
Dr. Leonard A. Harris
Mr. Joseph Maltz
Mr. Douglas Michel

Visitors

Mr. Sid Blecherman - Pratt & Whitney Aircraft
Mr. Harold Bullis - Library of Congress
Mr. Lou Chibbard - Science Trends Magazine
Mr. Thomas J. Gilding - Thiokol Corporation
Mr. Thomas McAllister - Aluminum Company of America
Ms. Nancy Meredith - Science Trends Magazine

ROLL CALL

The eleventh meeting of the NASA Research and Technology Advisory Council, Committee on Materials and Structures, was convened at 9:00 AM, March 25, 1975, at NASA Headquarters, Washington, D.C. The meeting was attended by the members, guests, and visitors listed on pages iii and iv. The entire meeting was open to the public. The Chairman welcomed all present and introduced the new members: Dr. Smook of the duPont Company and Mr. Heldenfels of the Langley Research Center.

The minutes of the previous meeting were approved without change.

CHAIRMAN'S REPORT

Dr. Ashley reported on the RTAC (Council) meeting of November 7 and 8, 1974. He noted that issues identified by the committee chairmen and the RTAC itself were ordered into categories of: (A) policy, (B) technical issues, or (C) issues requiring further Committee or Council consideration. Items requiring NASA response (A and B) have been reviewed by Dr. Lovelace, the Associate Administrator for Aeronautics and Space Technology, and staff, and action concerning these will be reported at the next RTAC meeting.

Dr. Ashley emphasized the need for better response to submittal and distribution of members' reports prior to the meeting, and identification of critical issues by members. He requested the Secretary to alert members to meeting schedules and agenda at least two months prior to the meeting with submittal of members' reports one month prior.

He outlined the agenda for the present meeting and asked members to consider issues and questions they might address to Dr. Lovelace who was scheduled to meet with the Committee later in the meeting.

SECRETARY'S REPORT

Mr. Deutsch presented charts showing recent changes in the OAST organization. He also reviewed Research Center areas of emphasis, the work breakdown structures in the space and aeronautics programs, R&T base effort, funding allocations for base programs and systems technology programs, and the various initiatives in systems technology for the next five years.

The broader role for OAST in terms of research toward non-aerospace applications was exemplified by agreement between the NASA Office of Energy Programs and the Materials and Structures Division of OAST for management of Energy Office materials programs.

Mr. Deutsch also reported that the RTAC, Panel on Research will review the area of materials science during their future meetings.

Dr. Jaffee noted that there was an agreement between EPRI and NASA for assistance in studying hydrogen attack on steel at high temperatures.

Several members raised questions concerning the continued and increased emphasis on new initiatives vs. a level base program, and on possible dilution of effort resulting from involvement on non-aerospace programs.

Mr. Deutsch felt that there is a general government trend toward systems technology, and NASA programs reflected this to some extent.

The members discussed present university-NASA relationships. It was felt by the university members that fellowship grants were more beneficial to universities than research grants or contracts.

CRITICAL AEROSPACE MATERIALS

At the previous meeting, the Chairman appointed an ad hoc group to study the problem of critical aerospace material supply and possible solutions. The group was chaired by Dr. Jaffee, and consisted of Dr. Ansell, Mr. Peterson, and Mr. Hall.

Just prior to the present meeting, the group met to prepare a report of their findings and recommendations. Mr. Chasman attended for Mr. Peterson. Dr. Ansell did not attend. Mr. Joseph Maltz of NASA Headquarters also attended.

Dr. Jaffee reported to the Committee by first summarizing results of recent meetings of the Department of Defense and the American Society of Metals which addressed the question of critical materials.

The conclusions of these meetings were that additional studies are required and that there is national awareness and concern about the problem. He noted that there is a continuing NMAB committee to study various critical materials, and a new one is being formed to define R&D for conservation of chromium.

The complete report of the ad hoc group is contained in Appendix A. In summary, their findings and recommendations were:

1. That NASA keep abreast of other studies in this area, and coordinate current activities with other concerned agencies. In particular, it was recommended that NASA participate in the NMAB study on chromium conservation.

2. For near term, NASA should encourage other agencies' efforts on stockpiling and recycling. No need is seen for additional NASA R&D for near term solutions.

3. It was recommended that research by NASA on substitutes for both chromium and nickel in superalloys and stainless steels be instituted now as a long term solution. Cooperation with other agencies, such as DOD, DOC, and DOI, was also recommended.

Discussion

Dr. Ansell challenged some of these recommendations from the viewpoint that the aerospace community is not the major user of either chromium or nickel. Therefore, he recommended that NASA initiate research to find substitute materials for the non-aerospace alloys as well as engage in research for chromium substitutions. This would reduce the demand for the critical materials and make them more available for aerospace applications. He felt these goals are not being pursued now because of the relatively low cost of chromium and nickel.

Dr. Jaffee stated that concentration of research on aerospace applications will produce benefits regardless of the chromium supply situation.

Mr. Ryan asked about other agencies and their responsibilities. Mr. Deutsch noted that other agencies are represented on the NMAB Committees.

Mr. Siegel stated that substitutes for chromium were questionable as complete solutions. He agreed that partial substitution is a likely possibility, but it was not probable that either nickel or chromium could be entirely replaced in superalloys.

Mr. VerSnyder felt that there would be no substitute for chromium in coatings and none for nickel in superalloys.

Recommendation

The Chairman suggested that both Dr. Jaffee's group report and Dr. Ansell's minority report be included as Committee reports on the subject. The Committee agreed. The Chairman requested that the working group continue to examine the question for further consideration at future meetings.

ENGINE TURBINE MATERIALS AND LIFE PREDICTION

Recommendations made by the Committee during the previous meeting, in response to a request by the Aeropropulsion Committee, resulted in formation of an ad hoc group to investigate the subject of prediction of engine materials properties. A group was organized consisting of Mr. Williams as Chairman, and Drs. Ashley and Mar.

Mr. Williams organized a NASA sponsored mini-symposium to focus on the specific question of life prediction of advanced turbine blades. This was held at the Ames Research Center on January 13-14, 1975.

Mr. Williams reported on the results of the symposium and noted that a recent Air Force survey of turbine blade problems provided a good base of information for the symposium. These studies showed that 25 to 30% of all blade problems are caused by high and low cycle fatigue and large payoffs would result from increased service life.

The NASA symposium was attended by representatives of the major turbine engine producers, Air Force Materials Lab, Air Force Propulsion Lab, Naval Air Propulsion Test Center, Langley and Lewis Centers, as well as Mr. Williams and other members of the ad hoc group. Copies of the symposium report were given to the Committee members. The complete report is contained in Appendix B.

Conclusions from the symposium, in summary, were:

1. The necessary inputs for making useful life predictions are essentially identical for solid, hollow, and film cooled blades.

2. The type of conventional materials property data needed is the same for the three types of blades and similar for isotropic and anisotropic materials.

3. A shortage of conventional materials property data is not likely to handicap overall development of life prediction methods for film cooled blades.

4. Methods of dynamic and thermal stress analysis have improved so that they are not a major impediment to the life prediction process.

5. The limiting factor in the development of life prediction methods for all turbine components is the development and verification of suitable life prediction models.

On the basis of these conclusions, the ad hoc group acknowledged and endorsed:

1. Coordination of research programs in turbine materials, particularly relating to life prediction by DOD and NASA.

2. A joint industry/government committee to periodically review government plans and industry needs in the area of life prediction as now planned by the Air Force Aero-Propulsion Laboratory.

The group recommended:

1. Government laboratories should continue to develop and verify life prediction models for both initiation and propagation phases of failure.

2. Continued monitoring of developments associated with formation of the joint industry/government committee by the RTAC Committee.

Discussion

Several members asked about the life prediction process and what data were considered basic. Mr. Williams explained that the process is computerized with regard to stress prediction and to some extent for life determination, but not for failure prediction. Basic data would include tensile properties, creep, fatigue life, etc. Dr. Mar pointed out that engine design is largely empirical. Temperature distribution in blades is a big problem.

Membership on the proposed government/industry committee being established by the Air Force was discussed. It was pointed out that it would include NASA membership.

The proprietary nature of most engine materials properties has precluded analysis and verification testing outside of engine manufacturers' facilities. A need was expressed for agreement on a few common non-proprietary materials which could be checked in government laboratories.

Recommendation

On the basis of Mr. Williams' presentation and the discussion, the Committee recommended:

1. Acceptance of the endorsements and recommendations of the Ad Hoc Group as stated in their report.

2. Use of non-proprietary materials common to several research programs for analysis and testing to allow accurate verification of life prediction methods.

3. Transmittal of a letter to the Air Force Aeropropulsion Laboratory which includes the Ad Hoc Group endorsements and recommendations and the the recommendation for common materials.

4. A memorandum to the RTAC Committee on Aeropropulsion similar to Item 3.

5. Action on Items 3 and 4 to be taken by the Secretary.

NASA OUTLOOK FOR SPACE STUDY

At the RTAC (Council) meeting, all Committee Chairmen were requested by Dr. Lovelace to have their Committees' review and make recommendations on the report by the NASA study team on the Outlook for Space for the 1980-2000 period.

Dr. Ashley requested Messrs. Hedrick and Siegel to review the preliminary results of the study. Mr. Hedrick reported on his review of a report, prepared by Working Group V of the Outlook for Space Panel. This was a draft copy of an abridged version of "A Forecast of Space Technology." The forecasts pertaining to materials and structures were found in Volume V, Part IV, "Acquiring and Processing Inanimate Matter - Macrostructures."

Mr Siegel had not completed his review in time for the meeting and promised to transmit his comments separately.

Mr. Hedrick's written comments were transmitted in a letter to JPL. He noted that several of the conclusions regarding materials and structures were not supported by the background information in the report. The report did not represent the necessary relationships among new materials, analysis, and structural design. Inputs from other NASA Centers were not evidenced.

He recommended that final Committee action on the study be deferred until Mr. Siegel's review was completed and until all members had read the study report.

Mr. Deutsch pointed out that an OAST Space Technology Workshop was being planned which would use the Outlook study in identifying new space experiments and technology. (See Shuttle Payload Technology.)

Action

The Chairman proposed that the subject be continued as an action item in future meetings until final Committee recommendations are made. The Committee concurred. Copies of Mr. Hedrick's comments will be transmitted to OAST members of the Outlook study group.

SHUTTLE PAYLOAD TECHNOLOGY

Mr. William H. Kinard, Manager of the Long Duration Exposure Facility (LDEF) project office at the Langley Research Center presented a review of the LDEF program. He described the LDEF as one part of the NASA Space Technology Payloads Program. Planning and objectives for the program are being defined through the OAST Space Technology Workshop. The Workshop organization consists of an OAST steering group, technology groups with NASA and Air Force members, user groups from other NASA program offices, and support groups.

The LDEF is a space test facility which will hold 5,000 lbs. of experiments. Once it is released from the Shuttle, there will be no connection with or dependence on that vehicle until retrieval, approximately 6 months later. Each experiment within the LDEF will be self-contained, and essentially passive. Data analysis will be performed in the laboratory after retrieval and return to earth. The LDEF will be gravity-gradient stabilized.

Mr. Kinard noted that the initial experiments were primarily identified from and supporting ongoing OAST space technology programs. The NASA Offices of Applications, Space Science, and Manned Space Flight have been invited to participate with a limited number of experiments, and there will be instrumentation supporting the Shuttle Orbital Flight Test (OFT) requirements. A list of candidate experiments from universities, industry, DOD, and NASA Centers was shown.

Mr. Kinard also described the responsibilities of the LDEF Shuttle Bay Environment Measurements Panel which included the definition of the specific measurements, during the OFT using the LDEF, a review of specifications for these measurements, and the evaluation of the post-flight analyses.

A schedule for LDEF development was shown. Launch readiness is to be achieved by mid-1979.

Discussion

Dr. Ansell asked about the value of LDEF experiments relative to total research community needs in terms of producing important results. Mr. Kinard responded by noting that experiments were subject to continuous review prior to flight and substitution of experiments would be made if re-evaluation so required. He also mentioned that all OAST offices were involved in identifying experiments and this type of overview would help to assure quality projects.

Action

The Chairman suggested that, since the dates for the actual experiments were 4 years in the future, no recommendations need be made concerning specific experiments at this time. The Committee concurred, and endorsed the LDEF concept as a cost effective and inexpensive approach to a space laboratory facility.

NEW ISSUES

Dr. Lovelace's Questions

Prior to the meeting, Dr. Lovelace formulated four questions which were addressed to all RTAC Committees. These were sent to all members for review and comment prior to the meeting. They were discussed as follows:

1. What could and should NASA do to aid in early distribution of NASA results to U.S. manufacturers?

Mr. Deutsch explained that a fundamental consideration here was the NASA FEDD policy (For Early Domestic Dissemination) which favored rapid and early transmittal of NASA sponsored research and technology program data to U.S. manufacturers, while restricting dissemination abroad.

Mr. Hedrick reviewed a number of comments from his organization which favored continuing present types of NASA publications (TN's, TR's, TM's) which are considered to be of high quality. In addition, it was recommended that a monthly or bi-monthly digest from each Center, with information on recent new projects, be published and widely distributed to U.S. organizations. These reports would not contain data, but would be organized in disciplinary categories. Individuals in organizations interested in particular items would contact the Center for details. Center personnel would determine and control the recipient's use of the information.

Mr. Turner recommended that specialists' conferences or workshops be scheduled at Centers on a semi-annual basis to provide perspective over a broad area.

Mr. VerSnyder noted that the Air Force approach used to disseminate manufacturing technology, by means of briefings either by government or industry at the conclusion of significant activities, was an effective method.

The NASA representatives felt that short written digests on quarterly or bi-monthly intervals would not be a burden for most Centers and would accomplish useful results. Conferences required more effort and some involved extensive research personnel time in preparation.

Ms. Barriage noted that participation in actual meetings provided more identity and incentive for the researcher and should be encouraged.

Dr. Ashley summarized these comments by stating that there are several types of conferences and modes of disseminating research, each of which serves a particular purpose. He asked the Committee to endorse short discipline oriented quarterly or bi-monthly written Center reports as the earliest and quickest aid to disseminating information. The Committee agreed.

2. What workshops and seminars would be useful to you and appropriate for NASA and NASA/DOT sponsorship?

Committee members reiterated that informal conferences would be productive. Mr. Hedrick suggested semi-annual workshops in particular disciplines. Dr. Smook recommended some kind of follow-up to determine if the information presented is actually used.

Mr. VerSnyder stated that workshops and seminars are useful when they are restricted to assessment of major emerging technologies such as composites and directionally solidified eutectics or complex technology situations such as critical strategic materials.

Most members agreed that the mini-symposium on specific topics was a very productive method, since it involved contributions from all attendees who were usually there by invitation. The following subjects were suggested:

Transonic Aerodynamics for Active Control Systems

Sonic Fatigue

Structural Optimization

High Temperature Materials (specific items)

Fracture Mechanics in Composites and Turbine Components

Fire Retardant Materials

Structural Dynamics (specific items)

3. Are there technology problems not receiving attention, or receiving too little attention, that are more important than some of the things OAST is doing? What are they?

Most of the members expressed concern that more effort should be given to base technology, even at the expense of systems technology development. Mr. Hedrick felt that NASA was rapidly becoming purely administrative and a shift toward NACA type operation was essential. He cited the NASTRAN program as a case in point, where funds and manpower would have been better invested in advancing the base program with in-house research.

Mr. Hall responded that both in-house and contracted operations were needed. Mr. VerSnyder added that facilities exist in many places and should be utilized.

Dr. Ansell felt that emphasis on systems were the result of the way the NASA program is organized. Many application programs contained base technology research.

Mr. Ryan noted that the Navy looks to NASA for aeronautical expertise and steps should be taken to safegurad these capabilities by continued in-house programs.

Dr. Jaffee pointed out that manpower requirements for monitoring large contracts were small in contrast to those involved in many small in-house programs.

The Committee listed a number of specific items on which more emphasis should be placed:

a. Life prediction methods for high-strength light alloys.

b. Increased in-house effort on energy related materials in cooperation with ERDA and other agencies.

c. Heat exchangers.

d. Establishment of a credible fatigue life prediction method.

e. Basic research in alloy and alloy-development theory.

f. Development of allowable strength mechanisms for and failure criteria for metallic and composite material combinations.

g. Systematic approach to bonded joint design and failure.

h. Fracture mechanics of ductile materials.

i. Dynamics and control. (Enhancement and integration of NASA vehicle dynamics and control activity as set forth in the report of the Joint Ad Hoc Panel on Aerospace Vehicle Dynamics and Control.)

4. Within a given disciplinary area (materials and structures) what are the fruitful potential areas of research to reduce aircraft fuel consumption?

The Chairman judged that contributions resulting from weight reductions were the major improvements to be obtained from materials and structures. Specifically, the Committee recommended the following:

a. Continuing development of materials permitting higher sustained turbine-inlet temperatures and higher pressure ratios in turbojet engines.

b. Greater application of composites.

c. Application of load alleviation principles through use of stability augmentation and control configured vehicle design.

An additional item suggested by Mr. VerSnyder was: Turbine sealing to reduce gas paths and losses.

The Chairman informed all members that he would prepare a letter to Dr. Lovelace summarizing Committee comment on the four questions and listing recommendations. A draft of the letter will be sent to the members for review and comment prior to being sent to Dr. Lovelace.

Other Issues

NASA Computer Programs - The Committee re-examined their position on NASA's Integrated Program for Aerospace Vehicle Design (IPAD) in the light of previous comments concerning the effectiveness of NASTRAN and its continued maintenance.

Mr. Douglas Michel of the Materials and Structures Division of OAST reviewed the plan and schedules for IPAD development. He noted that industry will be involved one month following contract initiation, and will continue to participate on the evaluation board. The risk to NASA and industry was low since major evaluation of the program will be done at 2 year intervals at which times decisions can be made to stop or make changes.

He distributed copies of a letter which contained an IPAD prospectus. This had been sent to 41 senior executives in various aerospace companies in February, 1975, and invited their participation as members of an advisory board during IPAD program development. It also included a request for a commitment to IPAD maintenance and improvement.

Messrs. Hedrick and Siegel expressed concern about IPAD being a long term commitment for NASA and industry. If it is successful, it will be a useful tool in aircraft design, but large companies will have to take steps in this direction on their own in the meantime.

Mr. Heldenfels commented that a consensus for IPAD development has existed even prior to the present program plan. He further noted that, contrary to the reported deficiencies, the NASTRAN program has been extremely cost effective, especially to many non-aerospace users. IPAD is expected to be a major improvement in the design of aerospace vehicles and will be applicable to other systems as well.

Dr. Ashley requested Dr. Mar to report at the next meeting on responses to the letter inviting industry participation. He also asked members to review the prospectus which was enclosed with the letter. Dr. Mar commented that the program development has been endorsed by a majority of potential users, and was endorsed by the Committee during the previous meeting.

Crashworthiness - Mr. Colin Simpson of the FAA pointed out that there was gap in the area of design for crash loads. Little information is available. Mr. Heldenfels stated that behavior of aircraft structures under crash conditions might be improved and that the present program at Langley would eventually provide data useful toward improvement.

The Chairman appointed Messrs. Colin Simpson, Heldenfels, and William Simpson to an ad hoc panel to study the problem and report at the next meeting.

Energy Program Materials - Several members discussed materials related or important to current R&D on energy sources. Dr. Mar noted that there are other panels or committees at work on the subject, such as a Congressional Committee study, "National Commission on Materials Policy," and a National Academy of Sciences study. Dr. Jaffee recommended that a Committee input now would be premature and this was also the consensus of the rest of the members.

Advanced Composite Design - Dr. Mar stated that some programs incorporating advanced composites into aircraft have leap-frogged problems which have shown up later in failures and designs which did not meet their goals, particularly in military aircraft. Mr. Siegel admitted that some failures are caused by manufacturing problems and some by design errors. All are not susceptible to analysis. However, he felt that in each case it was a matter of detail rather than any fundamental fault with composites. Mr. Chasman added that the Air Force is studying specific failures to determine causes and improvements. Mr. Siegel will try to provide the Committee with information at the next meeting. No immediate action was recommended, although it will be reconsidered at the next meeting.

Aircraft Service Life - The question of determining lifetime limits for aircraft in service was discussed. It was stated that the Air Force is conducting a program wherein limit load tests are run on B-52's from which a determination is made of remaining service life. There may be much data available from DOD and FAA on both airframe and engine components. Mr. William Simpson noted that Boeing has done considerable work on improving old designs. Mr. Turner offered to search out Boeing data on the subject. Mr. Colin Simpson will also try to provide data at the next meeting.

Dr. Smook suggested that this may be a problem for composite materials and perhaps specifications need to be formulated for resins and other polymers in this regard.

The Chairman appointed an ad hoc panel to define the problem. The members are Drs. Smook, Ansell; Messrs. Chasman and Siegel.

Rotary Wing Technology - Mr. Ryan stated that, although there is considerable research on this subject, including several Navy programs, more is needed on design approaches which will guarantee success. Present methods are largely empirical.

Both Messrs. Heldenfels and Williams responded by noting that NASA has an intensive program covering many facets of the design problem both at Langley and Ames. The large Army sponsored programs were also noted.

The Chairman requested that arrangements be made to have the subject reviewed at the next meeting with presentation by the Army, Navy, and NASA.

General Comment - The members discussed the need for Committee review of past recommendations from the standpoint of determining whether they are still applicable and also if NASA has taken the recommended action. Both Mr. Turner and Dr. Ansell felt that reiteration of some subjects was necessary from time-to-time.

Dr. Ansell suggested that there was need for small scale projects involving major new approaches and large problems as forcing functions for further materials and structures improvements.

DISCUSSION OF NEW ISSUES WITH DR. LOVELACE

Dr. Lovelace discussed new issues and other matters of concern with the Committee during the meeting.

On the subject of technology dissemination, Dr. Lovelace stated that the transition of new technology to users was a problem regardless of whether such technology was generated by industry or in-house by NASA. He therefore endorsed all methods which will accelerate and facilitate the transition, including the approaches suggested by the members.

He felt it was also important that the Committee should keep track of past recommendations to NASA and asked the Secretary to make a check of past items and inform the members of the NASA responses to them.

The Chairman discussed the NASA "Outlook" studies and asked about Committee review of the one for aeronautics. Dr. Lovelace stated that the aeronautics study had not progressed as far as the space study, but it was his intention to receive RTAC and Committee input at the appropriate time.

The Chairman also reviewed the members' comments regarding Dr. Lovelace's four questions.

Dr. Lovelace concluded his remarks by emphasizing the value of Committee advice and noted that the assistance of some of the members may be requested during future Congressional hearings on the NASA budget.

NASA CENTER REPORTS

Langley - A report on highlights of Langley research activities was distributed prior to the meeting. Mr. Heldenfels provided further information on tests of composite specimens and new approaches to three dimensional transonic loads research.

Ames - A copy of the Ames report was distributed to all members. Mr. Williams described some of the items in this report, including the status of ILLIAC, and heat pipe research at Ames. It was noted that an application of the heat pipe principle was being developed under contract with McDonnell-Douglas for the trans-Alaskan pipeline.

Lewis - Mr. Hall amplified some of the items described in his written report, including modified stainless steel alloys and new eutectic systems. He showed vugraphs of recent impact on boron-aluminum composites specimens and on engine fan blades made from these materials.

MEMBERS' REPORTS

The following members provided written reports to the Committee prior to and during the meeting:

Dr. Ashley - Selected Research at Stanford University

Dr. Ansell - NASA Research at R.P.I.

Ms. Barriage - Status Report on Selected R&D in FAA

Mr. Hedrick - Grumman Aerospace Research

Dr. Jaffee - EPRI Program Emphasis for 1975

Dr. Mar - MIT Research Sponsored by NASA and DOT
MIT Annual Report of Research in Materials

Mr. Chasman - Recent AFML Activities

Mr. Ryan - Naval Air Systems Command Report

Mr. Siegel - McDonnell-Douglas Aircraft Research Report

Mr. Turner - Boeing Research Report

Mr. VerSnyder - Materials for Advanced Gas Turbines at Pratt & Whitney Aircraft

Among the highlighted items orally described by the members in reviewing their reports were the following:

Mr. Colin Simpson showed vugraphs on FAA work on crash survivability and fire safety. These programs are related to NASA studies on the same problems such as anti-misting fuels research, cabin compartment fire safety, flight uniforms, and crash tests of general aviation aircraft.

Dr. Jaffee noted that EPRI will be studying fracture of large pressure vessels.

Dr. Mar described student work on the application of the Monte-Carlo method to crack-growth data as a low cost approach using analog computers.

Mr. Chasman mentioned an Air Force study on future mission capabilities vs. future technical goals which was similar to the NASA "Outlook" studies. This was part of a new Air Force investment strategy for future planning.

Mr. Ryan described recent applications of a fiberglass blade with a titanium leading edge to the H-46 helicopter.

Mr. VerSnyder noted that engine companies now recognize a changing development climate wherein military and civil aircraft engines are designed to separate goals and requirements. This is being reflected in present Pratt and Whitney program plans.

Dr. Ashley mentioned recent work at Stanford using finite element analysis on catenary vibrations. He also suggested that a visit to Stanford might be arranged during the next meeting. He also mentioned his involvement in an ad hoc committee for the Office of Manned Space Flight which was concerned with structural-material problems in manned spacecraft systems and suggested a NASA review of Shuttle problems during the next meeting.

PLANS FOR NEXT MEETING

The Committee planned to meet at the Ames Research Center on September 11 and 12, 1975. The agenda will include the following items:

Outlook for Space Report

IPAD Status Report

Crashworthiness Panel Report

Aircraft Aging Data Report

Aircraft Life Prediction Panel Report

Composites Failure Report

Rotary Wing Research

Shuttle Structural Problems

The meeting was adjourned at 3:00 PM on March 26, 1975.

Respectfully submitted,

Norman J. Mayer
Recording Secretary

APPENDIX A

REPORT
OF
AD HOC GROUP ON
CRITICAL AEROSPACE MATERIALS

Charge

To determine if further study or recommendations for research and development is needed on the problems of supply and/or substitution of present and future alloying materials used in aerospace applications.

Further Study of the Problem

Finding - There have been many national meetings held and study groups, including one at NASA Lewis led by R. Hall, on the problem of critical materials availability. The NMAB has been conducting a continuing study of various critical materials, and is attempting to initiate a new study, particularly aimed at research and development on conservation of chromium.

Recommendation - NASA should keep abreast of current studies of the critical materials problem. It should coordinate its activities with those of other agencies concerned. Specifically, we recommend that it participate in the upcoming NMAB study of chromium conservation as part of an integrated national effort.

Near Term R&D

Finding - There appears to be no immediate crisis in the supply of alloying elements for aerospace applications. There are several potential shortfalls in critical materials availability, largely of an economic or political nature.

Recommendation - NASA should keep track of and encourage the efforts of other agencies to build up an economic stockpile of critical materials, and should encourage the recycling of critical aerospace materials such as titanium and superalloys. No need is seen for additional NASA research and development for the near term.

Long Term R&D

Finding - There are four alloying elements essential to aerospace that are dependent on foreign supply. These are aluminum (from bauxite), titanium (from rutile), chromium, and nickel. Aluminum can be produced from domestic minerals such as kaolin clay, with an increase in the cost of aluminum of the order of 10 percent. Titanium can be produced from domestic ilmenite. It is reported that the U.S. possesses hugh resources of low-grade sulfide deposits of nickel. Also, there is a long-term expectation that deep ocean mining of manganese nodules will alleviate nickel (and cobalt) shortage problems. Only chromium has no obvious supply alternative.

Recommendation - No research and development seems to be needed for aluminum from clay and titanium from ilmenite, as the technology is reasonabily well in hand, and is being demonstrated under the support of other agencies.

In regard to chromium and nickel, we recommend that NASA forthwith should initiate research and development on substitute alloys for chromium and nickel in superalloys and stainless steels. We believe there are several viable alloying approaches for the partial replacement of these alloying elements. We recommend also that NASA follow closely the research and development of other organizations in substituting for chromium and nickel in their major usage applications, as this would free chromium and nickel for continued usage in aerospace applications. In particular, NASA and DOD should actively cooperate to drive an appropriate national approach, which would involve Commerce and Interior.

R. Jaffee
R. Hall
B. Chasman
J. Maltz
G. Ansell

MINORITY REPORT

Since critical shortages are anticipated in the supply of chromium and nickel, metals which are essential for alloys used for aerospace applications, it is necessary for NASA to take measures which will either insure future supplies of these metals or provide alternative alloy substitutions to metals not believed to become in short supply.

For the case of chromium, it is believed that for some applications, alloy development programs can fruitfully reduce the requirements for this metal for aerospace applications.

For nickel, it is unlikely that alloy development programs can substantially reduce the requirements for this metal for aerospace applications.

Since aerospace applications are a minor fraction of the total United States use of these critical metals, it is necessary to provide materials alternatives for these other than aerospace applications so as to reduce the overall U.S. requirements for chromium and nickel in order to protect the anticipated non-substitutable use of chromium and nickel for aerospace applications.

On this self-interest basis, it is recommended that:

1. NASA initiate programs to reduce the U.S. dependence on chromium for aerospace applications.

2. NASA initiate, in conjunction with other appropriate agencies, such as DOD and ERDA, programs to reduce the overall U.S. use of chromium and nickel in order to insure the future availability of these metals for critical aerospace applications.

G. Ansell

APPENDIX B

REPORT TO THE

MATERIALS AND STRUCTURES RTAC

from

The Ad Hoc Subcommittee on

Life Prediction of Advanced Turbine Blades

Background

The RTAC on Materials and Structures met on September 19 and 20, 1974 and discussed the request of the Aeronautical Propulsion RTAC that the former committee examine some materials considerations related to the development of advanced turbine blades containing film cooling holes. Specifically, the RTAC on Aeronautical Propulsion had concluded that "the shortage of basic materials data (creep, fatigue, crack initiation and propagation, etc.) is a problem and will handicap the overall development of life prediction methods" for such blades.

As a background for the Materials and Structures Committee's discussion, Mr. Marvin Hirschberg of NASA's Lewis Research Center presented a review of properties data requirements for turbine materials. In subsequent discussions, the Materials and Structures Committee agreed with the Aeronautical Propulsion RTAC that the requirements to determine the effects of the utilization of film cooling holes in turbine airfoils on low cycle fatigue life, and on the application of life prediction methods might exceed the current technology base. However, they felt that it was not clear whether this development was likely to be limited by the lack of an adequate data base or rather, by the inadequacy of current analytical models. The Materials and Structures Committee noted that resolution of this issue is complicated by the wide variety of blade materials currently in use and proposed for future application; it was noted that as more anisotropic and less homogeneous blade materials are used, this issue will be further exacerbated.

The RTAC Chairman appointed the following ad hoc subcommittee within the Materials and Structures RTAC to investigate this problem more fully:

Mr. Dell P. Williams, NASA/Ames, Chairman
Professor James W. Mar, MIT
Professor Holt Ashley, Stanford

Through informal discussions, the Subcommittee decided that NASA should sponsor a mini-symposium to consider materials requirements for the continued development of advanced turbine blades containing film cooling holes. It was felt that this symposium should have the structure of a workshop and should include as participants, experts from both government and industry in the areas of engine materials and engine design.

The NASA-sponsored symposium on Life Prediction of Advanced Turbine Blades was held on January 13-14, 1975 at the Ames Research Center, Moffett Field, California. The list of attendees and the agenda for the symposium are included in Appendix I of this report. The presentations and resulting discussions were limited to failure modes caused by the initiation and propagation of cracks due to thermal and dynamic stresses and to prediction of failure caused by these modes. The participants did recognize, however, that failure could occur by a variety of modes not considered, including oxidation, FOD, etc.

It was the feeling of the Subcommittee that the symposium was productive and that it succeeded in answering some important questions concerning the critical needs of the engine industry as regards the life prediction of advanced turbine blades. The following sections of this report describe the conclusions and recommendations of the Subcommittee based on results of the symposium.

SYMPOSIUM REPORT

Discussion

There is currently a good appreciation within both government laboratories and the engine industry of the need for an improved capability to predict the life of turbine engine components. Various programs directed toward this need are either being planned or are currently underway under the sponsorship of such government organizations as the Air Force Aeropropulsion Lab (AFAPL), Air Force Materials Lab (AFML), Naval Air Propulsion Lab, Air Force Office of Scientific Research (AFOSR), and NASA. In addition to these explicit government-sponsored programs, most companies are undertaking work in this area on IR&D and company funds. Improved life prediction capability is important not only for the design of advanced blades but also to accomplish life extension of existing flight hardware. This latter aspect is becoming increasingly important as the cost of turbine blades increases due to the use of both advanced configurations and exotic materials.

Advanced turbine blade configurations include solid blades, hollow (cooled) blades, and hollow blades containing film cooling holes. All types of configurations are finding use in both military and commercial aircraft engines. Additionally, the materials finding application in the newest blade designs include both conventionally cast (isotropic) and directionally solidified (anisotropic) materials. It is anticipated that, for some applications, these two types of materials will be supplemented in the future by eutectic alloys.

The symposium addressed the critical needs of the industry concerning life prediction of advanced turbine blades, and based on the presentations and discussions, the Subcommittee was able to reach the following general conclusions:

Conclusions

1. The necessary inputs for making useful life predictions are essentially identical for solid, hollow, and film cooled blades. These inputs include: An adequate supply of conventional materials property data, a detailed analysis of thermal and dynamic stresses, and suitable life prediction models. The degree of complexity of the analysis and even the need for certain analytical tools may, however, vary with the complexity of the blade.

2. The type of conventional materials property data needed is the same for solid, hollow, and film cooled blades and is similar for both isotropic and anisotropic materials. The materials properties data required includes information on creep, fatigue, thermal expansion, elastic and tensile properties, and thermal conductivity. The information for anisotropic materials is similar except that certain property data may be required in more than one blade direction.

3. A shortage of conventional materials property data is not likely to handicap the overall development of life prediction methods for film cooled blades. Data gathering activities have traditionally been done by the various gas turbine companies, and, because of the proprietary nature of the materials involved, the industry representatives felt, and the Subcommittee agrees, that it would be extremely difficult for anyone else to undertake the task. Based on the symposium discussions, it appears that data gathering activities by all major turbine engine manufacturers are proceeding satisfactorily.

4. Methods of stress analysis used in defining the dynamic and thermal stresses on turbine blades have improved significantly in the past few years and should not represent a major impediment to the life prediction process. The recent improvements have often been driven by the needs created by advanced blade configurations; however, once available, the methods of analysis have been applied to all new designs and often to reanalysis of old designs. It is recognized by

the Subcommittee, however, that there is a continuing need for support of work on stress analysis by both government and industry in order to decrease the cost and complexity of such methods and to make them more generally applicable.

5. Presently, the limiting factor in the development of life prediction methods for all turbine components is the development and verification of suitable life prediction models. Such models, which include both creep/fatigue criteria for crack initiation and fracture mechanics type criteria for propagation are necessary to help determine and verify design life and to accomplish life extension.

Endorsements and Recommendations

On the basis of the discussions of the symposium and the conclusions listed in the preceding section, the Ad Hoc Subcommittee makes the following endorsements and recommendations:

1. The Subcommittee acknowledges the coordination of research programs in the area of turbine materials by the Air Force and NASA and endorses this activity, especially as it relates to life prediction of engine components.

2. The Subcommittee acknowledges the desirability of a joint industry/government committee to periodically review both the government plans and the industry needs in the area of life prediction of engine components, and endorses the planned formation of such a committee under the sponsorship of the Air Force Aeropropulsion Laboratory.

3. The Subcommittee recommends that the government laboratories should continue to develop and verify life prediction models for both the initiation and propagation phases of failure. In these programs, suitable generic alloys representing both isotropic and anisotropic materials should be used along with their associated coatings.

Verification testing should be conducted at a variety of levels from test specimens to full scale components in representative turbine environments and considering appropriate configurations.

4. The Subcommittee recommends that the Materials and Structures RTAC should monitor the developments associated with the formation of a joint industry/government committee on engine component life prediction under Air Force sponsorship. Depending on the outcome of this activity, the RTAC should consider recommending future industry/government symposia dealing with this subject.

APPENDIX I

AGENDA FOR

NASA MINI-SYMPOSIUM ON

LIFE PREDICTION OF ADVANCED TURBINE BLADES

January 13-14, 1975

Building N-240
Ames Research Center
Moffett Field, California

Chairman - Dell Williams, NASA/Ames

Monday - January 13

8:45 - 9:00	Welcome, Introduction Dell Williams, NASA/Ames
9:00 - 9:45	Review of AF Survey of Life Prediction of Conventional Turbine Blades Richard H. Hill, AFAPL/TBP
9:45 - 10:30	Overview of AF Program on Crack Propagation Criteria for Turbine Components Walter H. Reimann, AFML/LLN
10:30 - 10:45	Break
10:45 - 11:30	Review of NASA Program on Life Prediction of Turbine Components Marvin H. Hirschberg, NASA/Lewis
11:30 - 12:30	Lunch
12:30 - 3:30	Identification of Critical Problem Areas from Industry Viewpoint

I. Pratt and Whitney, Aircraft Division
Allen Hauser
Karl Thomas

II. Detroit Diesel, Allison Division
Mehmet Doner
William Springer

III. General Electric Co.
Russell E. Duttweiler
Henry J. Brands

3:30 - 3:45	Break
3:45 - 5:00	IV. Garrett Corporation, AiResearch Mike Tovey
5:00	Adjourn for Day
7:30	No-Host Dinner "Mings" (Palo Alto)

Tuesday - January 14

8:30 - 11:30	Discussion of Critical Issues
11:30 - 12:30	Lunch
12:30 - 4:30	Prepare Recommendations NASA concerning Advanced Turbine Blades

List of Attendees

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